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Probing spin-2 ultralight dark matter with space-based gravitational wave detectors in the mHz regime

Spin-2 ultralight dark matter (ULDM) is a viable dark matter candidate and it can be constrained using gravitational wave (GW) observations. In this paper, we investigate the detectability of spin-2 ULDM by space-based GW interferometers. By considering a direct coupling between spin-2 ULDM and ordinary matter, we derive the corresponding response functions and sensitivity curves for various time-delay interferometry channels and calculate the optimal sensitivity curves for future millihertz GW detectors. Our results demonstrate that the space-based detectors can place stringent constraints on the coupling constant of spin-2 ULDM, reaching alpha ~ 10^(-10) around a mass of m ~ 10^(-17) eV, surpassing current limits from ground-based detectors and pulsar timing arrays. Thus, the space-based GW detectors can serve as powerful tools not only for detecting GWs but also for probing fundamental properties of ultralight dark matter.

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